ALLIANCE FOR THE CHESAPEAKE BAY
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Climate change already affecting Bay, experts say

By Karl Blankenship

Since the 1960s, water temperatures in the Chesapeake have warmed by about 2 degrees. In the mid-Atlantic, the period between the first and last accumulating snowfalls has decreased seven days in the last 50 years.

In the last century, Bay water levels have risen by more than a foot. About a dozen islands have vanished; others have been evacuated. Thousands of acres of shoreline marshes have eroded away.

Those were some of the examples scientists and others presented to a recent Senate committee hearing to illustrate that climate change is not a distant concern for the Bay region-it's a problem now.

"Global climate change is not something that is off in the Chesapeake Bay's future," Donald Boesch, president of the University of Maryland's Center for Environmental Science, told lawmakers at the hearing. "It is here today. The Bay is warming and evidence is growing that this is the case."

At the Sept. 26 hearing, the Senate Committee on Environment and Public Works heard from scientists, fellow lawmakers, governors and others who-for the most part-voiced concerns that the changing climate will make Bay cleanup efforts more difficult, threaten coastal communities and jeopardize species long associated with the Chesapeake, including striped bass and blue crabs.

"The impacts of climate change must be factored into restoration goals and actions," Boesch said. "No longer should this be put off as too hypothetical, too political or too daunting."

In addition to eroding islands and tidal marshes, climate change is already threatening key parts of the Bay ecosystem. Warm temperatures in the summer of 2005 are blamed for the massive die-off of eelgrass in the Chesapeake, a seagrass which provides essential habitat for young blue crabs and other species.

"No underwater grasses, no crabs, no fish, no shellfish," Will Baker, president of the Chesapeake Bay Foundation, summed up for the committee.

Future projections call for continued sea level rise of 1.2-4.5 feet in the Bay this century, further warming and increased winter and spring rainfall-a period critical to Chesapeake water quality.

Such changes are expected to make efforts to restore the nation's largest estuary even more difficult. Oxygen-starved "dead zones" will likely worsen; nutrient and sediment runoff may increase; and water conditions may be more favorable to harmful algae blooms and oyster diseases, according to testimony at the hearing. A series of recent reports and scientific papers echo those concerns.

Virginia Gov. Tim Kaine and Maryland Gov. Martin O'Malley urged the committee to pass legislation to reduce greenhouse gas emissions. Kaine noted that Virginia had made a tenfold increase in Bay-related spending in recent years. "We don't want to see the work that we're starting to do in earnest be jeopardized by what we are seeing in the area of climate change," he said.

O'Malley said many states have started to take action to combat climate change. Maryland recently adopted California Clean Car standards; joined the Regional Greenhouse Gas Initiative, which will reduce emissions from power plants; and formed a Commission on Climate Change to recommend further action.

Nonetheless, O'Malley said, "We cannot go it alone. We need a partnership with our federal government. The time to act is past. The time to catch up is now."

Concerns go well beyond Bay cleanup efforts. Kaine said the Hampton Roads region, with 1.7 million people, is the second most vulnerable population to sea level rise after New Orleans. "The storm vulnerability of that region is already something that is critical," Kaine said. Besides people, rising water will threaten the infrastructure that supports them-roads, utilities, sewage and drainage systems.

The slow encroachment of tidal waters will be magnified during extreme events, such as hurricanes and tropical storms, when storm surges will temporarily bring water several feet higher-in 2003, the storm surge associated with Hurricane Isabel raised water levels up to 9 feet in places, flooding areas that had never seen tidal waters before.

Scientists expect the frequency and severity of such storms to increase as the climate warms, increasing the threat to coastal areas.

The rising waters and erosion associated with increased storms will erase some of the Bay's remaining marshes and drown tidal wetlands, which provide important habitat for waterfowl, fish and crabs, as well as help to filter pollution.

States may need to modify land use regulations to help preserve tidal marshes. In a report that coincided with the hearing, the National Wildlife Federation said that Maryland and Virginia may need to designate "wetland migration corridors" to allow tidal wetlands to migrate upland as sea level rises. The states also need to discourage hard shorelines and structures in coastal march environments, it said.

The buffers Maryland and Virginia now require of new development to protect sensitive areas will not be adequate as water levels rise, the report added.

While the anticipated climate change may bring some benefits-commercially valuable species that live to the south may come into the Bay, for instance-scientists expect most changes will be problematic.

"The tally sheet of reasonable expectations is heavily tilted toward the detrimental in terms of ecosystem recovery," Boesch said in written testimony to the committee.

The full consequences of warming are difficult to anticipate. For instance, Boesch said that earlier warming in the spring places out of sync the arrival of striped bass and other spawning fish with the production of the food that is critical to the survival of their young.

Changes upstream could have a major impact on water quality. Climate change is likely to alter the makeup of the region's forests, potentially favoring species that are less effective at absorbing nitrogen -meaning more nutrient pollution could be exported downstream. In addition, warmer conditions would likely make forests more susceptible to to pest infestations, which would also increase nitrogen export.

Climate change will also mean current Chesapeake cleanup strategies need to be re-examined. Bay Program nutrient and sediment cleanup goals were set with computer models that used average hydrologic conditions from past years-conditions that may be far different from those in years and decades to come.

Of particular concern is the amount, timing and intensity of rainfall in the future, which directly affect the amount of nutrients and sediment entering the Bay. Nitrogen is highly water soluble, and "wet" conditions tend to drive more of it into the Chesapeake than dry periods.

The runoff of sediment and phosphorus-which often binds with sediment-increases during heavy, pounding rains, which have more erosive power.

Boesch said climate models also suggest that precipitation will likely increase during the key winter and spring period. Summertime water quality-especially dissolved oxygen conditions and the size of the Bay's summer "dead zone"-is largely determined by the amount of water and nutrients flushed off the land during that period.

"Higher winter-spring runoff will require even more efforts to control non-point source pollution in order to receive the same water quality goal for the Bay," Boesch said.

Warming temperatures are likely to lead to more intense weather events such as pounding thunderstorms. That raises concerns about the future effectiveness of many runoff control practices-from stormwater detention ponds to agricultural best management practices-which become less efficient as the amount and intensity of rainfall increases.

"It is increasingly likely that detention pond designs based on historic precipitation requirements may not meet performance goals under future conditions," noted Chris Pyke, a former climate scientist with the EPA and a member of the Bay Program's Scientific and Technical Advisory Committee, in written testimony to the panel.

Pyke said hundreds of millions of dollars are being spent by state, federal and local governments to install runoff controls-expected to last for years, if not decades-that may be overwhelmed by future storms.

"In this context," Pyke said, "climate change is an immediate concern for efforts to protect and restore water quality and living resources."

Pyke, who is leading efforts to write a report on climate change ramifications for the Chesapeake, called for a Baywide Climate Action Plan that would include a detailed road map for research and management actions to help meet Bay cleanup goals under changing climatic conditions.

But some argue such actions are pointless. Dennis Avery, a scientist with the Hudson Institute, expressed skepticism that any climate change around the Bay could be linked to human activity. He contended that warming patterns recur on cycles running roughly 1,500 years.

"They may not be the changes we prefer, but I seriously question our ability to stop them," Avery said. He suggested that efforts to restore the Bay instead focus on curbing corn production for ethanol-many scientists have warned that growing more corn will lead to more nutrient pollution.

"The biofuels program is greatly intensifying corn production and may be intensifying pollution problems in the Bay as a result," Avery said. "That is one thing that we could rein in even though we can't control the sun."

Others contended that changes were happening right before their eyes.

Richard Edmund, pastor of the three United Methodist churches which serve the tiny communities on Smith Island, told the committee that the signs of a changing climate are hard to ignore.

When Hurricane Isabel hit the region in 2003, it covered most of the marsh areas of Smith Island and entered the homes of some of the island's 225 residents-something that had never happened before.

Residents who never, or rarely, had water in their yards at unusually high tides now experience such flooding, Edmund said. Winter snow and freezes many islanders remember rarely occur. Crabs and oysters have declined. And brown pelicans, which never used to live so far north, are now nesting just off the island.

Smith Island, Edmund said, is the "canary in the coal mine." A sea level rise of an additional 3 feet, he said, would end practical living on Smith Island. "The effects will be felt on our communities first, but all of us are vulnerable to the results in some way," Edmund said.

"It is our desire that this committee and other bodies who have decision-making abilities would take action as quickly as possible to slow down the efforts that more and more each day seem certain to occur."

What's Good For The Chesapeake is Often Good For The Globe

Policy decisions made at the state and federal level can help reduce pollution to the Chesapeake Bay as well as help mitigate global warming. Some examples:

Protect existing and promote additional forests**.** Acre for acre, forests release less nitrogen, phosphorus and sediment into waterways than any other land use in the Bay watershed. As a rule of thumb, whenever forests are lost, it results in an increase in pollution.

The soil, plants, trees, forest floor and dead woody material of the Chesapeake watershed forests also store about 2 billion metric tons of carbon, according to "The State of Chesapeake Forests" report, completed last year by The Conservation Fund and the U.S. Forest Service. Those forests continue to absorb an additional 17 million metric tons of carbon annually. The watershed's forests are among the most effective in the nation in storing carbon, according to the report.

The loss of forest land threatens the carbon storage potential of Chesapeake Bay forests. Between 1990 and 2000, the region lost about 1.6 million metric tons of annual storage capacity because of forest loss.

Urban trees and associated soils also have the potential to sequester large amounts of carbon and have the added benefit of helping to regulate local climate, thereby reducing the demand for energy, which will reduce carbon dioxide emissions.

Promote agricultural best management practices. Many of the nutrient control actions that help to reduce nutrient and sediment runoff from farms provide the added benefit of sequestering carbon from the atmosphere. An acre of streamside forest buffer, for instance, can sequester 3,036 pounds of carbon a year, while an acre of no till farming sequesters 506 pounds and an acre of grass buffer sequesters 440 pounds, according to a recent report from the Chesapeake Bay Foundation.

Citing work conducted by a team of graduate students from the Yale School of Forestry and Environmental Studies, the report said 4.8 million metric tons of carbon would be sequestered annually if all agricultural best management practices called for in state tributary strategies (river specific cleanup plans for the

Bay) were implemented. That's enough to offset the emissions of 750,000 sport utility vehicles, according to the report, "Climate Change and the Chesapeake Bay: Challenges, Impacts and the Multiple Benefits of Agricultural Conservation Work."

Those best management practices would also reduce the amount of nitrogen reaching the Bay by about 65 million pounds, or about 60 percent of what's needed to clean up the Chesapeake.

***Promote cellulosic ethanol*.** Several recent reports warn that stepping up corn production to make ethanol would likely increase nutrient and sediment runoff into streams and the Bay. And because corn requires so much energy to produce, corn-based ethanol results in minimal reductions in greenhouse gas emissions.

But switching to switchgrass for ethanol production can sharply reduce nutrient and sediment pollution while absorbing large amounts of carbon from the atmosphere. A recent report for the Chesapeake Bay Commission, "Biofuels and the Bay," said that if 1 million acres of switchgrass were grown for ethanol in the Bay watershed (with 23 percent coming from row crops and the rest coming from other agricultural lands such as hay and pasture) it would reduce nitrogen pollution to the Bay by 25 million pounds a year, or about a quarter of the cleanup goal.

Switchgrass also produces several times as much energy per acre as corn. Replacing fossil fuels with ethanol from switchgrass offers the potential for significant reductions in C02 emissions-more than four times greater than that of corn ethanol. Also, many scientists believe that the extensive root system of switchgrass would allow the perennial plant to sequester carbon in its roots and adjacent soil even as the top of the plant is cut and used for energy.

Some states are moving to speed the development of ethanol from switchgrass and other cellulosic sources, which is largely an experimental process so far. California has a "low carbon fuel standard" that requires transportation-related energy use to reduce carbon emissions 10 percent by 2020. Part of the goal is to ensure that ethanol comes from cleaner sources.

Impacts of Climate Change on the Chesapeake Bay

Changes in the Bay Sea Level

One of the most certain changes is that water levels in the Bay will rise. During the last century, Bay water levels rose a bit more than a foot, the result of both sea level rise and land subsidence around the Chesapeake. (Land around the Bay was raised during the last ice age because of the weight of glaciers to the north. With the demise of those glaciers, is has been slowly subsiding for thousands of years.) The United Nations' International Panel on Climate Change projected global sea level rises of 1.2-2.5 feet for this century. More recent studies have projected a global sea level rise of 2.1-4.5 feet by the end of the century. Whatever happens globally, the increase in the Bay will be greater because of continued subsidence. Even with the

lowest projections, it is likely that Bay water levels will rise at least twice as much this century as last century.

Temperature

Temperatures in the region have increased by nearly 2 degrees Fahrenheit since 1960. Computer models suggest that air temperatures in this region will warm a further 5-9 degrees by the end of this century, with warmer summers and milder winters expected as a result. In recent decades, warmer air temperatures have correlated with warmer temperatures in the Bay.

Precipitation

Computer models suggest rainfall in the region could increase, especially in the winter and spring. Wetter conditions tend to drive more nutrients into the Bay. If that happens in the spring, it could exacerbate the growth of algae blooms, which are largely fueled by nutrients from the spring runoff. Scientists also expect warmer conditions to lead to more intense storms, which would increase erosion.

Salinity

Another uncertainty is how salinity will change. As sea level rises, more saltwater will move into the Bay from the ocean and potentially move farther up the Chesapeake. But salinity will also be influenced by precipitation patterns; if winter-spring rainfall increases, more freshwater will come down the rivers.

Dissolved Oxygen

Oxygen concentrations in the Bay are likely to worsen. Warm water holds less oxygen than cold water. Also, s trong flows in later winter and early spring would contribute to strong stratification between bottom and surface waters in the Bay, which prevents the two layers from mixing. As a result, when bottom areas become depleted of oxygen, they cannot easily be replenished from the surface, leading to larger "dead zones."

Impacts of Living Resources

Underwater Grasses

Eelgrass, historically the most widely distributed and abundant underwater grass in the Bay, is near the southern edge of its range and is very sensitive to prolonged water temperatures higher than 30 degrees Celsius (86 degrees Fahrenheit). A warm spell in 2005 caused an extensive eelgrass die-off in the Bay. A continued warming trend could severely reduce eelgrass abundance. It is the dominant seagrass in high-salinity areas of the Bay; if it were lost, there would be nothing to replace it in many areas. That would take a toll on such species as post-larval blue crabs, which depend on eelgrass beds near the mouth of the Bay to hide in when they return after spending months in the coastal ocean. It is also the only perennial grass to persist in

large amounts over the winter, providing a year-round source of food and refuge for waterfowl and other aquatic species. Other grasses in the Bay are annual plants, coming to life each spring as temperatures warm up.

Freshwater species of underwater grasses, which have been recovering in the Bay, could have their range restricted if climate change results in more areas of high-salinity water.

Tidal Marshes

The Bay has already been losing marshes as sea level rises faster than wetlands can migrate upland, and that could accelerate. Tidal marshes are important habitat for waterfowl, blue crabs and many fish. They also play an important role in filtering pollution.

A recent analysis found that about 1,700 square kilometers of land in Virginia and Maryland are less than 0.7 meters above current sea level, and about half of that is wetlands. As sea level rise accelerates, many landowners will try to harden their shorelines with bulkheads or riprap to stop erosion, thereby preventing the migration of marshes.

Another concern is that warmer temperatures will be more conducive to nutria, a muskrat native to South America that chews the roots of marsh grasses, making areas more susceptible to erosion. Nutria have contributed greatly to marsh losses on Maryland's Eastern Shore, where efforts are under way to eradicate the rodent. But a warmer climate may make it easier for the species to expand its range.

Waterfowl

Wintering waterfowl on the Chesapeake could see a sharp decline for three reasons. First, the Prairie Pothole Region in the upper Great Plains where most ducks wintering on the Bay breed is expected to become much drier and produce two-thirds fewer ducks by some estimates. Second, as the climate warms, some migrating waterfowl will stop in ice-free areas farther north and west to spend the winter, no longer completing their migration to the Chesapeake. Finally, waterfowl that return to the Bay will find a loss of shallow water wintering habitat, including marshes and underwater grass beds, as sea level rises and water temperatures warm.

Fish

Some species that are at the southern end of their range, such as winter flounder and the economically important soft-shelled clam could largely disappear from the Bay as temperatures warm.

But the Chesapeake could become home for species that live primarily to the south today, such as the brown shrimp, southern flounder, black drum, grouper and spotted seatrout.

A changing climate would likely be problematic for other species as well, such as striped bass and Atlantic sturgeon, both of which prefer cooler water with high-oxygen levels. Other species whose abundance may decrease in the Bay include Atlantic menhaden, blue crab and eastern oyster.

Fish and other organisms also typically require more oxygen when temperatures rise because their metabolism increases. For example, the endangered shortnose sturgeon requires at least 3.2 milligrams of dissolved oxygen per liter of water at all times to survive. But when water temperatures increase to 29 degrees Celsius, (about 84 degrees Fahrenheit) they need at least 4.3 mg/l of oxygen, thus requiring more oxygen as it becomes more scarce.

Some consequences are hard to predict. In some areas, a rise in temperatures has resulted in earlier spring blooms which are no longer timed to the production of "grazers" -including larval fish-which normally eat the algae, something that could fundamentally alter the food chain.

Disease

Oyster diseases MSX and Dermo fare better in high salinities. Studies show that a trend toward warmer winters is conducive for the oyster diseases MSX and Dermo to expand their range. If salinity increases, it would also promote more intense disease infections in Bay oysters.

Some scientists believe warmer conditions would aid in the spread of mycobacteria infections in striped bass. Because rising temperatures generally favor bacteria survival and production, warmer Bay waters could play host to an increasing number of human pathogens, including a variety of vibrio species that are associated with cholera and other diseases.

Complex Interactions

Fish and other species in the Bay will not face climate changes in isolation; they will likely face multiple climate-related stresses at the same time, magnifying the problems they face in an already degraded Chesapeake ecosystem.

An often cited example is the "temperature-dissolved oxygen" squeeze confronting striped bass. The fish try to avoid water warmer than 76 degrees Fahrenheit, usually by seeking refuge in cooler, deeper water. But striped bass also require higher levels of dissolved oxygen than many other fish, so deep water-which often contains less oxygen-is often off-limits. Some scientists believe that these stressful summer conditions may contribute to the widespread infection rate of mycobacteriosis, a chronic wasting disease, in Chesapeake Bay striped bass.

As temperatures warm, and dissolved oxygen concentrations decrease further, the Bay could become an increasingly stressful environment for striped bass. In addition, as available habitat is further squeezed, some believe mycobacteriosis infection rates could climb higher as striped bass are crowded together.

Striped bass are not the only fish to encounter such problems. Species like sturgeon are highly stressed by both warm temperatures and low-dissolved oxygen conditions. For sturgeon, the situation may be worse because they are bottom feeders, so low-dissolved oxygen also makes food sources off-limits.

Sources: EPA, Bay Program Scientific and Technical Advisory Committee, National Wildlife Foundation, Chesapeake Bay Foundation

Bay Program to adjust models to anticipate climate change scenarios

For years, Bay Program plans to restore the Chesapeake have been based on computer models that assume "average" future conditions. Recognizing that the future may differ sharply from the past, this will soon begin to change.

Next year, the Bay Program will begin an exercise to anticipate what the Bay-and watershed-may look like one to two decades from now under different management and climate scenarios.

It's working with EPA headquarters and other federal agencies to get data from a series of climate change models that provide a range of potential future climate patterns for the region. By looking at where those models agree on things such as future temperature and rainfall patterns, officials can identify what changes are most likely to shape the future in the Bay.

That information will then be used in the Bay Program's own computer models to assess how climate may affect the Chesapeake and restoration efforts.

"That allows us to put more of a Bay face on climate change," said Rich Batiuk, associate director for science with the EPA's Bay Program Office. "We can put it in real terms that say how is it going to make our efforts that much more difficult-or is it going to do so?"

Among the things the Bay Program hopes to learn:

Will climate change make attaining water quality standards-necessary to remove the Chesapeake from the EPA's "dirty waters" list-more difficult? For example, scientists believe changing climates may worsen dissolved oxygen concentrations in the Bay.

Will climate change reduce the effectiveness of the tributary strategies states have written to guide nutrient and sediment reduction efforts? It's possible some runoff control practices used in developed landscapes and on farms may become less effective if the frequency and intensity of rainstorms were to increase.

Will some runoff control actions become more desirable than others in the future? For instance, if precipitation patterns change, agricultural practices that absorb or detain water runoff may become more valuable than practices that only reduce nutrients.

Climate change will not happen in isolation, Batiuk said. Other factors affecting Bay water quality, such as changes in land use, will also affect cleanup efforts. So the Bay Program plans to pair alternative future land use scenarios with possible climate change scenarios.

"We'll learn as we go along. And as we understand and learn these things, we will try to build them into our decision making," he said.

Batiuk expects the Bay Program to begin running its model scenarios next spring and to begin reaching some conclusions about what types of impacts to expect, and how they might be addressed, by late next year.

Karl is the Editor of the Bay Journal.

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